भारतीय मानक
Indian Standard

IS 16644 : 2018

पूर्व प्रतिबलित कंक्रीट के लिए तनाव से रहित एवं कम शिथिलन वाले तार — विशिष्टि

Stress-Relieved, Low Relaxation Steel Wire for Prestressed Concrete — Specification

ICS 77.140.15; 91.080.40

© BIS 2018

भारतीय मानक ब्यूरो
BUREAU OF INDIAN STANDARDS
मानक भवन, 9 बहादुरशाह ज़फर मार्ग, नई दिल्ली-110002
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI-110002
www.bis.org.in www.standardsbis.in

May 2018 **Price Group 5**

Concrete Reinforcement Sectional Committee, CED 54

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Concrete Reinforcement Sectional Committee had been approved by the Civil Engineering Division Council.

In India, use of high tensile cold-drawn wire for prestressing of concrete is a long-established practice. It is used in structural components such as electricity poles, railway sleepers, precast reinforced pipes, etc. With the advent of manufacturing technology, low relaxation variety of stress relieved, cold-drawn prestressing steel wires are now being manufactured in the country. Usage of such wires leads to saving in material and thus construction cost and also promotes reliability of the structure.

This standard has been formulated to cover low relaxation variety of stress-relieved cold-drawn prestressing steel wires of either plain, indented or crimped surface.

Prestressing cold-drawn wires of normal relaxation variety are covered in following Indian Standards:

a) IS 1785 (Part 1) : 1983 Specification for plain hard-drawn steel wire for prestressed concrete: Part 1 Cold-drawn stress-relieved wire (s*econd revision*)
b) IS 1785 (Part 2) : 1983 Specification for plain hard-drawn steel wire for prestressed concrete: Part 2 As-drawn wire (*first revision*)
c) IS 6003 : 2010 Indented wire for prestressed concrete — Specification (*second revision*)

In the formulation of this standard, due weightage has been given to international coordination among the standards and practices prevailing in different countries in addition to relating it to the practices in the field in the country. Considerable assistance has been derived from the following International Standards in the formulation of this standard:

ISO 6934-1: 1991	Steel for the prestressing of concrete — Part 1: General requirements
ISO 6934-2: 1991	Steel for the prestressing of concrete — Part 2: Cold-drawn wire

Provisions in this standard are at variance with similar provisions in the above international standards. The major deviations along with reasons for the same are:

a) Ribbed bars are not covered in the standard as are not manufactured in the country.
b) Nominal size 3.0 mm, which is used in India, has been included in the standard which is not covered in international standard.
c) Nominal tensile strength grade of 1 860 N/mm^2 has been added to sizes 4.0 and 5.0 mm, as the same are likely to offer significant advantage to Indian customers in terms of reduced steel usage.
d) Unlike ISO standards, tolerance on nominal diameter has been specified in line with similar requirement in other Indian standards on steel reinforcement. Check on section by weighing has been specified only when the diameter measurements show an ovality of more than half of the total diameter tolerance.
e) 0.2 percent proof load has been specified in line with similar requirement in other Indian standards on steel reinforcement. Considering its ease of testing in a manufacturing set up, recording load at 1 percent extension as a measure of proof load has also been retained in this standard.

The Committee responsible for the formulation of this standard is given in Annex B.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis shall be rounded off in accordance with IS 2 : 1960 ‘Rules for rounding off numerical values (*revised*)’. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

STRESS-RELIEVED, LOW RELAXATION STEEL WIRE FOR PRESTRESSED CONCRETE — SPECIFICATION

1 SCOPE

This standard covers the requirements for the manufacture, supply and testing of plain, indented or crimped, cold-drawn, stress-relieved, low relaxation, steel wires.

2 REFERENCES

The standards listed below contain provisions which, through reference in this text, constitute provision of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

IS No.	*Title*
228	Methods of chemical analysis of steels:
(Part 3) : 1987	Determination of phosphorus by alkali metric method (*third revision*)
(Part 9) : 1989	Determination of sulphur by evolution method (for sulphur 0.01 to 0.25 percent) (*third revision*)
1387 : 1993	General requirements for the supply of metallurgical materials (*second revision*)
1608 : 2005	Metallic materials — Tensile testing at ambient temperature (*third revision*)
5074:1969	Method for axial load fatigue testing of steel

3 TERMINOLOGY

For the purpose of this standard, the following definitions shall apply.

3.1 Cast Analysis — Chemical analysis of a sample of the molten steel during casting.

3.2 Characteristic Value (C) — Value having a prescribed probability of not being attained in a hypothetical unlimited test series.

3.3 Coil — One continuous length of wire in the form of a coil.

3.4 Cold-drawn Wire — A wire product obtained from a rod by cold working through dies or rollers.

3.5 Elongation — The increase in length of a tensile test piece under stress. The elongation is conventionally expressed as a percentage of the original gauge length of a standard test piece.

3.6 Elongation at Maximum Force — The elongation corresponding to the maximum load reached in a tensile test.

3.7 Indentation — The creation of a depression or a series of depressions of particular shape and dimension on the surface of the wire by some mechanical process or otherwise without altering the mechanical and chemical properties.

3.8 Nominal Cross-sectional Area — The cross-sectional area equivalent to the area of a circular plain bar of nominal diameter.

3.9 Nominal Diameter of Indented/Crimped Wire — The nominal diameter of the indented/crimped wire is equivalent to the diameter of a plain wire having the same mass per unit length as the indented/crimped wire.

3.10 Parcel — Any quantity of finished wire presented for examination and test at any one time.

3.11 Proof Stress — The stress which produces a residual strain of 0.2 percent of the original gauge length (non-proportional elongation).

3.12 Relaxation — Time-dependent stress loss for a constant length. Relaxation is stated as a percentage of the initial stress applied to the steel.

3.13 Stress Relieved Cold-drawn Wire — Cold-drawn wire that has been subjected to one of the following treatments in a continuous linear manner:

a) The wire passes through a sequence of flexures followed by a short-term heat treatment; and
b) The wire is given a short-term heat treatment under plastic deformation (under conditions of longitudinal strain).

Both treatments improve certain mechanical properties and relaxation characteristics, method (b) giving lower stress relaxation.

3.14 Tensile Strength — The maximum load reached in a tensile test divided by the original cross-sectional area of the gauge length portion of the test piece.

3.15 Unit of Manufacture — Wire produced from one wire rod coil.

3.16 Unit of Product — Unit of manufacture or a smaller coil produced from the unit of manufacture.

4 TYPES OF PRESTRESSING COLD-DRAWN WIRE

Prestressing cold-drawn wires have been classified in following types based on their surface configuration:

a) *Plain wire* — Wire with a surface as obtained in the drawing die. The wire has a constant nominal cross-section and does not show periodical irregularities along the length in either the surface or axis.

b) *Indented wire* — Wire whose surface has indentations at regular intervals along the length.

c) *Crimped wire* — Wire which has a regular deformation of the wire axis in either a single plane or in helical form produced by a subsequent mechanical process.

5 MANUFACTURE AND CHEMICAL COMPOSITION

5.1 The wire shall be cold drawn from the steel made by the open hearth, electric, basic oxygen, or a combination of these processes. Air or mixed air/oxygen bottom blown processes shall not be employed for drawing the wire. In case any other process is employed in the manufacture of steel, prior approval of the purchaser shall be obtained.

5.1.1 The ladle analysis of steel when tested in accordance with IS 228 (Part 9) and IS 228 (Part 3) or any other established instrumentation testing method having similar accuracy and least count shall contains not more than 0.030 percent of sulphur and not more than 0.030 percent of phosphorus, respectively.

5.2 The wire rods obtained from the rolling mill shall be heat treated, if required to make it suitable for cold drawing and thereafter the diameter of the wire rod shall be successively decreased to the required diameter by cold drawing it through a series of dies. The resultant wire shall be subjected to straightening and stress relieving process.

5.3 All finished wires, subject to the provisions of **5.2** shall be clearly drawn to the specified size and shall be sound, free from splits, harmful surface flaws, piping and other defects likely to impair its use in prestressed concrete, and finished in a workmanlike manner.

5.4 The surface of wire shall be clean, uniform, smooth and free from harmful scratches, flat parts, longitudinal or transverse ribs, etc. Unless otherwise agreed to between the purchaser and the manufacturer/supplier, the wire shall not carry on its surface, lubricants or other matter to a degree likely to impair its adhesion to concrete. Slight rust may be permitted, provided there is no surface pitting visible to the naked eye.

5.5 There shall be no welds or joints in the finished wire as supplied to the purchaser. Any welds or joints made during manufacture to promote continuity of operations shall be removed before supply.

6 DIMENSIONS AND SURFACE CONFIGURATION

6.1 Nominal diameters of the finished wires, cross-sectional area, nominal mass and the tolerances applicable to these shall be as specified in Table 1.

6.1.1 For purpose of determining whether the actual diameter of the wire is within the specified tolerances, the diameter shall be determined with a micrometer by taking two measurements at right angles to each other at three places along a length of not less than 250 mm and the average of these six measurements shall be taken as the diameter of the wire.

6.1.2 Where the diameter measurements (taken in two directions at right angles in the same plane) show an ovality of not more than half of the total diameter tolerance, no checks on section by weighing shall be necessary. Where ovality is more than half of the total diameter tolerance, check on section by weighing shall be made.

6.2 Surface Configuration

The type of surface configuration (*see* **4**) and also its shape and pattern shall be as mutually agreed to between the manufacturer and the purchaser.

Examples of indentations and crimps are given in Annex A for information only.

NOTE — Surface configurations like ribs, indentations, crimps are provided on prestressing wires to improve bond properties between wire and concrete.

6.3 Straightness of the wire shall be determined by measuring height at the centre of a cord of 1 m length. The same should not exceed 25 mm.

7 MECHANICAL PROPERTIES

The wires shall conform to the physical requirements specified in **7.1** to **7.6**.

NOTE — For special purposes, test evidence may be required to show that the wire is not susceptible to stress corrosion. In such case, the test method shall be mutually agreed to between the manufacturer and the purchaser.

7.1 Tensile Strength

The tensile strength of wire, when determined in accordance with **8.3** and based on the nominal diameter of the wire shall be as specified in col 3 of Table 2. Wires with tensile strength values other than those indicated in Table 5 may also be supplied with mutual agreement between the purchaser and the manufacturer.

Table 1 Dimensional Properties of Wire

(*Clause* 6.1)

Sl No.	Dimensional Properties				
	Nominal Diameter mm	Permissible Tolerance mm	Nominal Cross- sectional Area mm^2	Nominal Mass g/m	Permissible Tolerance g/m
(1)	(2)	(3)	(4)	(5)	(6)
i)	3	±0.03	7.07	55.5	±1.5
ii)	4	±0.04	12.6	98.9	±2.0
iii)	4	±0.04	12.6	98.9	±2.0
iv)	4	±0.04	12.6	98.9	±2.0
v)	5	±0.05	19.6	154	±3.1
vi)	5	±0.05	19.6	154	±3.1
vii)	5	±0.05	19.6	154	±3.1
viii)	6	±0.05	28.3	222	±3.7
ix)	6	±0.05	28.3	222	±3.7
x)	7	±0.05	38.5	302	±4.3
xi)	7	±0.05	38.5	302	±4.3
xii)	8	±0.05	50.3	395	±5.9
xiii)	8	±0.05	50.3	395	±5.9
xiv)	8	±0.05	50.3	395	±5.9

NOTE — The nominal mass per length is calculated from its nominal cross- sectional area and the density of steel. The value adopted for density of steel is 7.85 kg/dm^3.

Table 2 Mechanical Properties of Wire

(*Clause* 7.1)

Sl No.	Nominal Diameter	Mechanical Properties					
	mm	Nominal Tensile Strength[1] MPa	Characteristic Maximum Force[2] kN	Nominal Stress at 1 Percent Extension MPa	Characteristic Value of Force at 1 Percent Extension[3] kN	Mandrel Radius for Reverse Bend Test mm	Maximum Relaxation at 1 000 h
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
i)	3	1 860	13.1	1 674	11.83	7.5	a) 2.5 percent for initial load equal to 70 percent of the characteristic value of maximum force b) 4.5 percent for initial load equal to 80 percent of the characteristic value of maximum force
ii)	4	1 670	21.0	1 503	18.89	10.0	
iii)	4	1 770	22.3	1 593	20.02	10.0	
iv)	4	1 860	23.4	1 674	21.04	10.0	
v)	5	1 670	32.7	1 503	29.51	15.0	
vi)	5	1 770	34.7	1 593	31.28	15.0	
vii)	5	1 860	36.5	1 674	32.87	15.0	
viii)	6	1 670	47.3	1 503	42.50	15.0	
ix)	6	1 770	50.1	1 593	45.04	15.0	
x)	7	1 570	60.4	1 41 3	54.38	20.0	
xi)	7	1 670	64.3	1 503	57.84	20.0	
xii)	8	1 470	73.9	1 323	66.50	20.0	
xiii)	8	1 570	79.0	1 41 3	71.03	20.0	
xiv)	8	1 670	84.0	1 503	75.55	20.0	

[1] The nominal tensile strength is for designation purposes only and is calculated from the nominal cross-sectional area and the characteristic maximum force and rounded off to the nearest 10 N/mm^2.

[2] In view of the small tolerance on mass per length, characteristic forces have been specified rather than stresses.

[3] The modulus of elasticity may be taken to be 205 ± 10 kN/mm^2.

7.2 Proof Stress

The proof stress of the wire, when determined in accordance with **8.4** shall be not less than 90 percent of its minimum specified tensile strength.

If required by the purchaser, proof stress at 0.1 percent or 0.2 percent offset may be tested. The same shall not be less than 83 percent and 85 percent of the specified characteristic maximum force, respectively.

7.3 Bending Ductility

The wires, when tested for reverse bend test as per **8.5** shall withstand at least following number of minimum bends around the bend radius as specified in col 7 of Table 2.

a) Plain wires : 4

b) Indented/Crimped wires : 3

7.4 Elongation

The percentage total elongation at maximum force, when measured over a gauge length of 200 mm in accordance with the method given in **8.6** shall be not less than 3.5 percent.

7.5 Relaxation

7.5.1 The relaxation at 1 000 h at an initial force of 70 percent of the characteristic maximum force specified in Table 2 shall be determined in accordance with the method given in **8.7** and the relaxation value shall not exceed 2.5 percent. If requested by the purchaser, the relaxation at 1 000 h shall be determined also at initial force of 80 percent of the characteristic maximum force (*see* Table 2) and the relaxation value in this case shall not exceed 4.5 percent.

Relaxation test for 1 000 h shall be a type approval test and shall be carried out at least once in a year or whenever there is any change in the process of manufacture, for each type and size of wire.

7.5.1.1 When it is not possible to conduct 1 000 h relaxation test, the wire may be accepted on the basis of 100 h relaxation test, provided the manufacturer furnishes proof establishing a relation between the relaxation stress values at 1 000 h and 100 h and provided that the relaxation values does not exceed 1.8 percent for initial force of 70 percent of characteristic maximum force and 2.5 percent for initial force of 80 percent of characteristic maximum force.

7.6 Fatigue

If agreed to between the purchaser and the manufacturer, the material when tested in accordance with the method given in **8.8** shall withstand, without failure, 2 x 10^6 cycles of a stress fluctuating down from a maximum stress of 70 percent of the nominal tensile strength. The stress range shall be 200 N/mm^2 for plain wire, 180 N/mm^2 for indented wire and 100 N/mm^2 for crimped wire.

8 TESTS

8.1 All test pieces of wire of sufficient length for the specified tests shall be selected by the purchaser or his authorized representative either,

a) from the cuttings of lengths of wires or ends of coils of wires, or
b) if so desires, from the coil or length of wire, after it has been cut to the required or specified length and the test piece taken from any part of it.

8.1.1 In neither case, the test piece shall be detached from the coil or length of wire, except in the presence of the purchaser or his authorized representative.

8.1.2 Before test pieces are selected, the manufacturer or supplier shall furnish the purchaser or his authorized representative with copies of the mill records giving the number of coils or bundles in each cast with sizes as well as the identification marks whereby each coil or bundle of wire can be identified.

8.2 Test samples shall not be subjected to any form of heat treatment. Any straightening which the test samples may require shall be done cold.

8.3 Tensile Test

The ultimate tensile strength shall be determined in accordance with IS 1608.

8.4 Test for Proof Stress

Proof stress shall be determined in accordance with IS 1608. Alternatively, stress at 1.0 percent extension under load method as specified in **8.4.1** may be determined.

8.4.1 When stress at 1.0 percent extension under load method is to be determined, an initial load corresponding to a stress of 196 N/mm^2 shall be applied to the test piece and a sensitive extensometer then attached. The dial of the extensometer shall be set to a reading equal to 0.001 mm/mm of the gauge length to represent the extension due to the initial load. The load shall be increased until the extensometer shows an extension corresponding to 1.0 percent of the gauge length, when the load shall be noted. The stress calculated for this load shall be not less than the value specified for the 0.2 percent proof stress.

8.5 Reverse Bend Test

The test piece taken in accordance with **8.1** shall be capable of being bent in the following manner without showing signs of fracture:

One end of the test piece shall be firmly gripped in a vice fitted with jaws having specific radius. The free end of the wire shall be bent round the appropriate radius specified in col 7 of Table 1 through an angle of 90° and then back to the original position; this constituting one bend.

8.6 Elongation

The elongation at maximum force shall be determined in accordance with IS 1608.

8.7 Test for Relaxation

The manufacturer shall provide evidence from records of tests of similar wire that the relaxation of load from an initial stress of 70 percent of the specified minimum tensile strength conforms to that specified in **7.5**. The initial load shall be applied in a period of 5 min and shall then be held constant for a further period of 1 min. Thereafter no adjustment of load shall be made, and load relaxation readings shall commence from the end of the sixth minute. On no account shall the test specimen be overstressed. During the whole period of test the temperature shall be maintained at 20 ± 2°C. Load readings shall be continuously recorded. Load recorded at the end of stipulated period of time shall be used to calculate relaxation loss.

8.8 Test for Fatigue Strength

The fatigue strength shall be determined in accordance with IS 5074.

9 SAMPLING AND CRITERIA FOR CONFORMITY

9.1 Scale of Sampling

9.1.1 *Lot*

In any consignment, all the coils of wire of the same nominal diameter and same type and manufactured at the same place under similar conditions of production and storage shall be grouped together to constitute a lot.

9.1.2 The number of coils to be selected at random from each lot shall depend upon the size of the lot and shall be in accordance with Table 3.

Table 3 Sample Size

(*Clause* 9.1.2)

Sl No. (1)	No. of Coils in the Lot (2)	No. of Coils to be Selected (3)
i)	Up to 25	3
ii)	26-65	4
iii)	66-180	5
iv)	181-300	7
v)	301 and above	10

9.2 Number of Tests

9.2.1 All the coils, selected as in **9.1.2** shall be tested for chemical composition (*see* **5.1.1**), nominal diameter (*see* **6.1**), tensile strength (*see* **7.1**), proof stress (*see* **7.2**), bending ductility (*see* **7.3**) and elongation (*see* **7.4**).

9.2.1.1 From each coil one test specimen shall be selected for all tests and tested in accordance with the appropriate test method.

9.2.2 If required by the purchaser, 100 h relaxation test (*see* **7.5**) shall be carried out on a sample from the lot.

9.3 Criteria for Conformity

9.3.1 The lot shall be considered as conforming to the requirements of the specification, if the conditions specified under **9.3.2** to **9.3.5** are satisfied for all the characteristics.

9.3.2 *Chemical Composition, Diameter, Tensile Strength and Proof Stress*

For each of the characteristics, the mean and the range calculated from the test results shall satisfy the appropriate conditions given below:

a) Mean + 0.6 Range, shall be less than or equal to the maximum specification limit, and
b) Mean – 0.6 Range, shall be greater than or equal to the minimum specification limit.

NOTE — The range is the difference between the maximum and the minimum value of the test results.

9.3.3 *Elongation*

In case of test for elongation at maximum force, every sample tested shall satisfy the requirements of **7.4** and the percentage elongation for none of the samples shall fall below the value specified in **7.4**.

9.3.4 *Ductility*

In case one or more of the test pieces first selected fail to pass this test, twice the number of samples originally tested shall be selected for testing. All the samples so tested shall satisfy the requirement of this test. Should any of the test pieces from these additional samples fail, the material represented by the samples shall be considered as not having compiled with this standard.

9.3.5 *Relaxation*

Should the sample first selected fail to pass the test, two further samples shall be selected for testing in respect of 100 h relaxation test. Should both the additional test samples pass the test, the material represented by the test samples shall be deemed to comply with the requirements of this standard. Should either of these additional samples fail, the material represented by the test sample ‘shall be considered as not having complied with this standard.

10 DELIVERY AND INSPECTION

10.1 Unless otherwise specified, general requirements relating to the supply of material, inspection and testing shall conform to IS 1387.

10.2 No material shall be dispatched from the manufacturer’s or supplier’s premises prior to its being certified by the purchaser or his authorized representative as having fulfilled the tests and requirements laid down in this standard except where the bundle or coil containing the wire is marked with the Standard Mark (*see* **11.2**).

10.3 The purchaser or his authorized representative shall be at liberty to inspect and verify the steel maker’s certificate of cast analysis at the premises of the manufacturer or supplier; when the purchaser required an actual analysis of finished material, this shall be made at a place agreed to between the purchaser and the manufacturer or supplier.

10.4 Manufacturer’s Certificate

In the case of wires which have not been inspected at the manufacturer's works, the manufacturer or supplier, as the case may be, shall supply the purchaser or his authorized representative with certificate stating the process of manufacture and also the test sheet signed by the manufacturer giving the result of each mechanical test and the chemical composition. Each test sheet shall indicate the number or identification mark of the cast to which it applies, corresponding to the number or identification mark to be found on the material.

10.5 When tests for susceptibility to stress corrosion and relaxation are required to be carried out, the cost of testing shall be borne by the purchaser.

10.6 Unless otherwise agreed to by the purchaser and the manufacturer, wire shall be supplied in coils of sufficiently large diameter to ensure that the wire can be uncoiled without difficulty, and without affecting the mechanical properties and the straightness of the wire. The minimum coil diameter shall be not less than 200 times the wire diameter. For wires up to 5 mm diameter, coils of inner diameter of about 1.5 m and for wires above 5 mm diameter, coils of inner diameter of about 2 m, without breaks, joints and welds are generally recommended. The mass of the coil shall be as mutually agreed to between the purchaser and the manufacturer or supplier. Each coil shall have at least four tight bindings/ligatures.

10.7 Packing, Transport and Storage

The coils of wire shall be packed as agreed to between the purchaser and the manufacturer. Prestressing wires shall be protected against damage and contamination during transport and storage, particularly from substances or liquids which are likely to produce or encourage corrosion.

11 IDENTIFICATION AND MARKINGS

11.1 The manufacturer or supplier shall have ingots, billets and wires, or coils of wires marked in such a way that all finished wire can be traced to the cast from which they were made. Every facility shall be given to the purchaser or his authorized representative for tracing the wires to the cast from which they were made. Each bundle or coil shall be securely attached with a tag/label bearing the following information:

a) Manufacturer's name or trade-mark or brand name;
b) Letter referring to wire surface configuration:
    P = plain,
    I = indented,
    C = crimped;
c) Nominal diameter of wire, in mm;
d) Nominal tensile strength of wire, in N/mm^2; and
e) Batch/Coil Number and cast/heat number.

11.2 BIS Certification Marking

Each bundle or coil containing the wires may also be suitably marked with the Standard Mark in which case the concerned test certificate shall also bear the Standard Mark.

11.2.1 The use of the Standard Mark is governed by the provisions of the *Bureau of Indian Standards Act*, 1986 and the Rules and Regulations made thereunder. The details of conditions under which the license for the use of Standard Mark may be granted to manufacturers or producers may be obtained from the Bureau of Indian Standards.

ANNEX A

(*Clause* 6.2)

EXAMPLES OF INDENTATIONS AND CRIMPS

A-1 INDENTATIONS

Figure 1 and Fig. 2 give examples of two widely used arrangement of indentations. The nominal dimensions of the indentations, which are related to nominal wire diameters are given in Table 4 and Table 5 for indentation Type T1 and T2, respectively. Other forms of indentations as agreed to between the purchaser and the supplier may also be used.

A-2 CRIMPS

Figure 3 gives example of two methods of crimping, helical and uniplanar. The total wave height (excluding the wire diameter) and pitch of crimping are given in Table 6. Other forms of crimping as agreed to between the purchaser and the supplier may also be used.

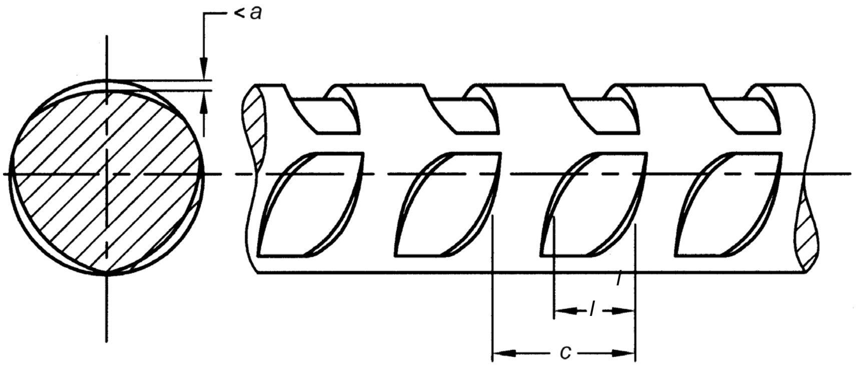
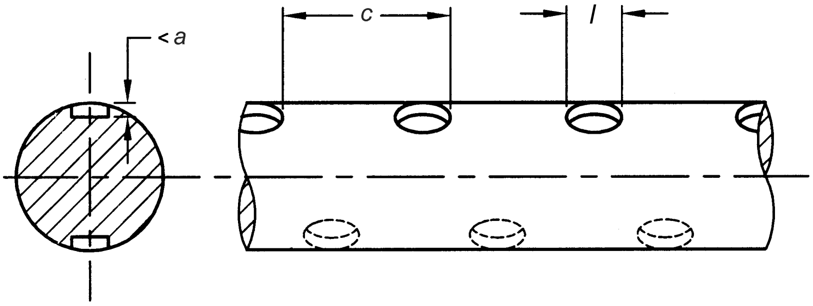


FIG. 1 INDENTATION TYPE T1 (TRIPLE INDENTATION)

Table 4 Nominal Indentation Dimensions for Type 1 (Triple Indentation)
(*Clause* A-1)
All dimensions in millimetres.

Sl No.	Nominal Wire Diameter d_{nom}	Nominal Indentation Dimension			
		Depth a	Tolerance on Nominal Depth	Length l	Spacing (Pitch) c
(1)	(2)	(3)	(4)	(5)	(6)
i)	≤ 5.0	0.06 - 0.13	± 0.03	3.5 ± 0.5	5.5 ± 0.3
ii)	> 5.0	0.09 - 0.16	± 0.04	5.0 ± 0.3	8.0 ± 0.3



NOTE — In case of indented wires, the indentations shall be placed in two lines, diametrically opposite and the opposite indentations shall be staggered so that no two indentations are exactly opposite.

FIG. 2 INDENTATION TYPE T2 (BELGIAN INDENTATION)

Table 5 Specified Indentation Dimensions for Type 2 (Belgian Indentation)
(*Clause* A-1)
All dimensions in millimetres.

Sl No.	Nominal Wire Diameter d_{nom}	Nominal Indentation Dimension			
		Depth a	Tolerance on Nominal Depth	Length l	Spacing (Pitch) c
(1)	(2)	(3)	(4)	(5)	(6)
i)	≤ 5.0	0.06 - 0.16	± 0.04	5.0 ± 1.0	8-18
ii)	> 5.0	0.06 - 0.16	± 0.04	5.4 ± 1.0	10-20

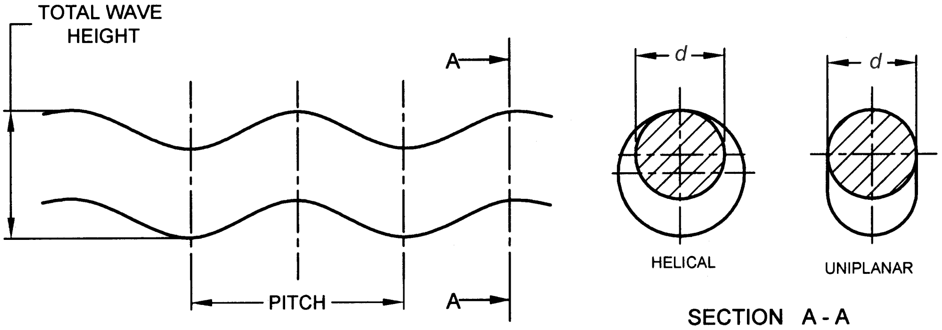


FIG. 3 CRIMPED WIRE

Table 6 Crimp Dimensions

(*Clause* A-2)

Sl No.	Type of Crimp	Pitch	Total Wave Height (Excluding Wire Diameter, *d*)	
			Helical	Uniplanar
(1)	(2)	(3)	(4)	(5)
i)	Short Pitch	5*d* - 10*d*	5 percent *d* - 10 percent *d*	10 percent *d* - 20 percent *d*
ii)	Long Pitch	8*d* - 12*d*	6 percent *d* - 12 percent *d*	12 percent *d* - 25 percent *d*

ANNEX B

(*Foreword*)

COMMITTEE COMPOSITION

Concrete Reinforcement Sectional Committee, CED 54

Organization	*Representative(s)*
In Personal Capacity (*17, Nalanda Apartment, D-Block, Vikaspuri, New Delhi 110018)*	Shri G. Sharan **(*Chairman*)**
Central Public Works Department, New Delhi	Shri A. K. Garg Shri Rajesh Khare (*Alternate*)
CSIR - Central Building Research Institute, Roorkee	Shri S. R. Karade Shri D. M. Mecon (*Alternate*)
CSIR - Central Electrochemical Research Institute (CSIR), Karaikudi	Shri K. Saravanan
CSIR - Central Road Research Institute, New Delhi	Director Shri S. S. Gaharwar (*Alternate*)
CSIR-Structural Engineering Research Centre, Chennai	Shri T. S. Krishnamoorthy Dr B. H. Bharathkumar (*Alternate*)
Central Water Commission, New Delhi	Director (HCD-NW&S) Director (HCD-N&W) (*Alternate*)
Construction Industry Development Council, New Delhi	Shri Sunil Mahajan Shri O. P. Gupta (*Alternate*)
Delhi Development Authority, New Delhi	Shri G. R. Shiromani Shri Lachhman Singh (*Alternate*)
Delhi Tourism & Transportation Development Corporation Limited, New Delhi	Shri Shishir Bansal
Dextra India Private Limited, Mumbai	Shri Sunil Desai Shri Jitendra H. Pathak (*Alternate*)
Engineer-in-Chief's Branch (MES), New Delhi	Brig Girish Joshi Lt Col Gaurav Kaushik (*Alternate*)
Engineers India Limited, New Delhi	Shri Rajanji Srivastava Shri Deepak Agrawal (*Alternate*)
Gammon India Limited, Mumbai	Shri Venkataramana N. Heggade Shri Sudeesh Rajendran (*Alternate*)
Hindustan Construction Company, Mumbai	Shri Satish Kumar Sharma Dr Chetan Hazaree (*Alternate*)
Indian Association of Structural Engineers, New Delhi	Shri Hari Om Gupta Shri Manoj K. Mittal (*Alternate*)
Indian Institute of Technology, New Delhi	Prof A. K. Nagpal Prof B. Bhattacharjee (*Alternate*)
Indian Stainless Steel Development Association, New Delhi	Shri Rohit Kumar Shri Jousline George (*Alternate*)
Institute of Steel Development and Growth, Kolkata	Dr Jayanta K. Saha Shri Arijit Guha (*Alternate*)
Jindal Steel & Power Limited, Gurgaon	Shri Ashwani Kumar Shri Lakshminarasimhan (*Alternate*)
JSW Steel Limited, Raigad	Shri Pratap K. Patra
Larsen and Toubro Limited (ECC Construction Division), Chennai	Shri S. Kanappan Shri Sthaladipti Saha (*Alternate*)
MECON Limited, Ranchi	Shri U. Chakraborty Shri J. K. Jha (*Alternate*)
Ministry of Road Transport & Highways, New Delhi	Shri S. K. Verma Dr Sanjay Wakchaure (*Alternate*)
Ministry of Steel, Government of India, New Delhi	Shri S. K. Bhatnager Shri Anil Kumar Mishra (*Alternate*)

Organization	*Representative(s)*
National Council for Cement and Building Materials, Ballabgarh	Shri V. V. Arora Shri Amit Trivedi (*Alternate*)
National Highways Authority of India, New Delhi	Shri M. P. Sharma Shri K. Venkataramana (*Alternate*)
National Institute of Secondary Steel Technology Association, Mandi Govindgarh	Shri Robin Kumar Bagchi Shri Vishvabandhu Gupta (*Alternate*)
National Metallurgical Laboratory, Jamshedpur	Dr D. D. N. Singh
NTPC Ltd, New Delhi	Shri A. K. Bansal
Nuclear Power Corporation India Limited, Mumbai	Shri Y. T. Praveenchandra Shri R. N. Sarangi (*Alternate*)
Outokumpu India Private Limited, New Delhi	Shri Yatinder Pal Singh Suri Shri Purushothama Reddy (*Alternate*)
P.S.L. Limited, Mumbai	Shri R. Radhakrishnan Shri Kunal Patel (*Alternate*)
Rashtriya Ispat Nigam Limited, Visakhapatnam	Shri C. H. Srinivasa Rao Shri G. Raja Lingam (*Alternate*)
Research Design and Standards Organization, Ministry of Railways, Lucknow	Shri Anil Kumar Shri A. K. Pandey (*Alternate*)
Steel Authority of India Limited, Bhilai Steel Plant, Bhilai	Shri U. K. Bhalla Shri Sanjay Kamra (*Alternate*)
Steel Authority of India Limited, Durgapur Steel Plant, Durgapur	Shri A. N. Banarjee Shri Abhijit Datta (*Alternate*)
Steel Authority of India Limited, R&D Centre for Iron & Steel, Ranchi	Dr Vinod Kumar Shri D. Karmakar (*Alternate*)
Steel Re-Rolling Mills Association of India, Kolkata	Shri B. M. Beriwala Shri Swapan Kumar Chakravorty (*Alternate*)
STUP Consultants Private Limited, Mumbai	Shri Amit Kumar Chakraborty Shri Anirban Sengupta (*Alternate*)
Sunflag Iron & Steel Co Limited, New Delhi	Shri R. K. Malhotra Shri Jagannathan Somu (*Alternate*)
Tata Steel Limited, Jamshedpur	Shri Biswajit Ghosh Shri Tanmay Bhattacharyy (*Alternate*)
Tata Steel Limited (Wire Division), Mumbai	Shri Shishir V. Desai Shri Suresh Mahajan (*Alternate*)
In personal capacity (*BC 96, Salt Lake City, Kolkata 700064*)	Dr Anil K. Kar
In personal capacity (*House No. 2310, Sector 7D, Faridabad 121006*)	Shri Harish Kumar Julka
BIS Directorate General	Shri Sanjay Pant, Scientist E & Head (Civil Engg) [Representing Director General (*Ex-officio*)]

Member Secretaries
Shri S. D. Rane
Scientist E (Civil Engg), BIS
and
Shrimati Madhurima Madhav
Scientist C (Civil Engg), BIS

Bureau of Indian Standards

BIS is a statutory institution established under the *Bureau of Indian Standards Act*, 1986 to promote harmonious development of the activities of standardization, marking and quality certification of goods and attending to connected matters in the country.

Copyright

BIS has the copyright of all its publications. No part of these publications may be reproduced in any form without the prior permission in writing of BIS. This does not preclude the free use, in the course of implementing the standard, of necessary details, such as symbols and sizes, type or grade designations. Enquiries relating to copyright be addressed to the Director (Publications), BIS.

Review of Indian Standards

Amendments are issued to standards as the need arises on the basis of comments. Standards are also reviewed periodically; a standard along with amendments is reaffirmed when such review indicates that no changes are needed; if the review indicates that changes are needed, it is taken up for revision. Users of Indian Standards should ascertain that they are in possession of the latest amendments or edition by referring to the latest issue of 'BIS Catalogue' and 'Standards : Monthly Additions'.

This Indian Standard has been developed from Doc No.: CED 54 (10572).

Amendments Issued Since Publication

Amend No.	Date of Issue	Text Affected

BUREAU OF INDIAN STANDARDS

Headquarters:

Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi 110002
Telephones : 2323 0131, 2323 3375, 2323 9402 *Website*: www.bis.org.in

Regional Offices: *Telephones*

Central : Manak Bhavan, 9 Bahadur Shah Zafar Marg
NEW DELHI 110002 — 2323 7617, 2323 3841

Eastern : 1/14 C.I.T. Scheme VII M, V. I. P. Road, Kankurgachi
KOLKATA 700054 — 2337 8499, 2337 8561, 2337 8626, 2337 9120

Northern : Plot No. 4-A, Sector 27-B, Madhya Marg, CHANDIGARH 160019 — 26 50206, 265 0290

Southern : C.I.T. Campus, IV Cross Road, CHENNAI 600113 — 2254 1216, 2254 1442, 2254 2519, 2254 2315

Western : Manakalaya, E9 MIDC, Marol, Andheri (East)
MUMBAI 400093 — 2832 9295, 2832 7858, 2832 7891, 2832 7892

Branches: AHMEDABAD. BENGALURU. BHOPAL. BHUBANESHWAR. COIMBATORE. DEHRADUN. DURGAPUR. FARIDABAD. GHAZIABAD. GUWAHATI. HYDERABAD. JAIPUR. JAMSHEDPUR. KOCHI. LUCKNOW. NAGPUR. PARWANOO. PATNA. PUNE. RAIPUR. RAJKOT. VISAKHAPATNAM.

Published by BIS, New Delhi